

# PATENT COOPERATION TREATY

## PCT

### INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY


(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

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Applicant's or agent's file reference 152456-0 DK		<b>FOR FURTHER ACTION</b>		See Form PCT/IPEA/416
International application No. PCT/IL2004/000678		International filing date (day/month/year) 25.07.2004	Priority date (day/month/year) 24.07.2003	
International Patent Classification (IPC) or national classification and IPC G02B3/00, G03F7/00				
Applicant EXPLAY LTD. et al.				
<p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 5 sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p>a. <input checked="" type="checkbox"/> sent to the applicant and to the International Bureau a total of 7 sheets, as follows:</p> <p><input checked="" type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).</p> <p><input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.</p> <p>b. <input type="checkbox"/> (sent to the International Bureau only) a total of (Indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</p>				
<p>4. This report contains indications relating to the following items:</p> <p><input checked="" type="checkbox"/> Box No. I Basis of the opinion</p> <p><input type="checkbox"/> Box No. II Priority</p> <p><input type="checkbox"/> Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p><input type="checkbox"/> Box No. IV Lack of unity of invention</p> <p><input checked="" type="checkbox"/> Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</p> <p><input type="checkbox"/> Box No. VI Certain documents cited</p> <p><input type="checkbox"/> Box No. VII Certain defects in the international application</p> <p><input type="checkbox"/> Box No. VIII Certain observations on the international application</p>				
Date of submission of the demand  23.05.2005		Date of completion of this report  15.11.2005		
Name and mailing address of the international preliminary examining authority:  European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016		Authorized Officer  Seibert, J  Telephone No. +31 70 340-4712		



**INTERNATIONAL PRELIMINARY REPORT  
ON PATENTABILITY**

International application No.  
PCT/IL2004/000678

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**Box No. I Basis of the report**

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1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
- ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
- ☐ international search (under Rules 12.3 and 23.1(b))
  - ☐ publication of the international application (under Rule 12.4)
  - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the **elements\*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report):*

**Description, Pages**

1-28 as originally filed

**Claims, Numbers**

1-57 received on 23.05.2005 with letter of 23.05.2005

**Drawings, Sheets**

1/5-5/5 as originally filed

- ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing
3. ☐ The amendments have resulted in the cancellation of:
- ☐ the description, pages
  - ☐ the claims, Nos.
  - ☐ the drawings, sheets/figs
  - ☐ the sequence listing (*specify*):
  - ☐ any table(s) related to sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
- ☐ the description, pages
  - ☐ the claims, Nos.
  - ☐ the drawings, sheets/figs
  - ☐ the sequence listing (*specify*):
  - ☐ any table(s) related to sequence listing (*specify*):

\* If item 4 applies, some or all of these sheets may be marked "superseded."

**INTERNATIONAL PRELIMINARY REPORT  
ON PATENTABILITY**

International application No.  
PCT/IL2004/000678

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**Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

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**1. Statement**

Novelty (N)	Yes: Claims	1-57
	No: Claims	
Inventive step (IS)	Yes: Claims	1-57
	No: Claims	
Industrial applicability (IA)	Yes: Claims	1-57
	No: Claims	

**2. Citations and explanations (Rule 70.7):**

**see separate sheet**

**Re Item V**

**Reasoned statement with regard to novelty, inventive step or industrial applicability;  
citations and explanations supporting such statement**

- 1 Reference is made to the following documents:  
D1: EP-A-0 523 861 (MITSUI PETROCHEMICAL IND) 20 January 1993 (1993-01-20)  
D2: US-A-5 235 463 (BROUSSOUX DOMINIQUE ET AL) 10 August 1993 (1993-08-10)
- 2 The document D1 is regarded as being the closest prior art to the subject-matter of claim 1, and shows (the references in parentheses applying to this document):  
A method of manufacturing a micro-optics structure having at least one lenslet array, the method comprising:
  - (A) providing a writing mask having a predetermined pattern of light transmitting regions configured in accordance with an arrangement of the lenslet array to be manufactured; and
  - (B) applying said writing mask to a structure formed by a photosensitive layer of a predetermined thickness carried by a substrate, and exposing the photosensitive layer through the writing mask using a predetermined spectral range of the exposure and a predetermined distance between the mask and said photosensitive layer defined by the arrangement of the lenslet array to be manufactured, thereby creating at the photosensitive layer a predetermined light intensity distribution corresponding to the desired shape of the lenslet array and forming a continuous pattern in the form of optical nonhomogeneities in the photosensitive layer material.
- 2.1 The subject-matter of claim 1 differs from this known method of manufacturing a micro-optics structure in that  
the predetermined pattern of light transmitting regions are defining a diffractive optical element; and  
a predetermined distance between the mask and the photosensitive layer defined by the arrangement of the lenslet array to be manufactured, so as to ensure diffraction interference of light at the photosensitive layer, thereby creating at the photosensitive

layer a predetermined light intensity distribution with different intensity levels corresponding to the desired shape of the lenslet array and forming a continuous pattern in the form of optical nonhomogeneities in the photosensitive layer material, thereby producing said at least one lenslet array within said photosensitive layer.

2.2 The subject-matter of claim 1 is therefore new (Article 33(2) PCT).

2.5 The problem to be solved by the present invention may be regarded as providing better defined lenslet arrays.

2.6 The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons:

There is not hint in the available prior art to use different intensity levels created by inference at a diffractive mask in the exposure step of a method of manufacturing a lenslet array.

Additionally there is not indication of the problem to be solved in the available prior art.

3 Concerning claim 57, a spatial light modulator device comprising a lenslet array manufactured by the method of claim 1 is distinguishable from a spatial light modulator device having a lenslet array as of D1 or D2.  
Therefore the subject-matter of claim 57 is considered to be novel and inventive (Article 33(2) and (3) PCT).

4 Claims 2-56 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

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**CLAIMS:**

1. A method of manufacturing a micro-optics structure having at least one lenslet array, the method comprising:
  - (A) providing a writing mask having a predetermined pattern of light transmitting regions defining a diffractive optical element configured in accordance with an arrangement of the lenslet array to be manufactured; and
  - (B) applying said writing mask to a structure formed by a photosensitive layer of a predetermined thickness carried by a substrate, and exposing the photosensitive layer through the diffractive optical element of the writing mask using a predetermined spectral range of the exposure and a predetermined distance between the mask and said photosensitive layer defined by the arrangement of the lenslet array to be manufactured, so as to ensure diffraction interference of light at the photosensitive layer, thereby creating at the photosensitive layer a predetermined light intensity distribution with different intensity levels corresponding to the desired shape of the lenslet array and forming a continuous pattern in the form of optical nonhomogeneities in the photosensitive layer material, thereby producing said at least one lenslet array within said photosensitive layer.
2. The method of Claim 1, wherein said substrate is a glass layer.
3. The method of Claim 1, wherein said substrate is a semiconductor structure.
4. The method of Claim 1, wherein said substrate is a layer structure of a pixel arrangement of a spatial light modulator (SLM).
5. The method of Claim 3, wherein said substrate is a layer structure configured as a matrix drive system of a pixel arrangement of a spatial light modulator (SLM).
6. The method according to any one of preceding Claims, wherein said photosensitive material is photoresist.

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7. The method of Claim 1, wherein said writing mask is configured as an incoherent light writing mask.
8. The method of Claim 7, comprising fabricating said incoherent light writing mask, the fabrication including:
  - 5 (i) creating a computerized file related to a pattern forming said incoherent light writing mask, the pattern being indicative of morphology of said micro-optics structure defining said at least one lenslet array;
  - (ii) plotting the file on a photo film, thereby creating an image related to the pattern;
  - 10 (iii) developing and fixing the photo-film;
  - (iv) minifying the image by imaging it on a milimask;
  - (v) copying the image from the milimask on a glass plate, whereby said glass plate is used as said writing mask.
9. The method of Claim 8, wherein said file is a postscript file.
- 15 10. The method of Claim 8, wherein said milimask is made of glass material.
11. The method of Claim 8, wherein said minifying of the image includes:
  - providing an undeveloped milimask coated with a light sensitive emulsion;
  - exposing the coated milimask to light radiation indicative of said image;
  - developing and fixing the milimask.
- 20 12. The method of Claim 8, wherein said copying of the image on the glass plate includes:
  - providing an undeveloped glass plate coated with a chrome and a positive photo-resist;
  - exposing said glass plate to UV light passing through said milimask;
  - 25 developing said glass plate;
  - placing the glass plate into chrome etcher; and
  - removing the photo-resist from the glass plate.
13. The method of Claim 12, wherein said exposing of said glass plate to UV light includes positioning said glass plate on a predetermined distance from the  
30 milimask by using a mask aligner.

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14. The method of Claim 7, comprising fabricating said incoherent light writing mask, the fabrication including :

- (i) creating a computerized file related to a pattern forming said incoherent light writing mask, the pattern being indicative of morphology of said micro-optics structure defining said at least one lenslet array;
- (ii) providing an undeveloped glass plate coated with a chrome and a photo-resist sensitive to e-beam radiation;
- (iii) drawing said pattern on the undeveloped glass plate by using e-beam technique;
- (iv) developing said glass plate;
- (v) placing the glass plate into chrome etcher; and
- (vi) removing said photo-resist from the glass plate.

15. The method of Claim 1, wherein said writing mask is a coherent light writing mask.

16. The method of Claim 15, wherein said writing mask is in the form of surface relief defining an array of protrusions spaced-apart by cavities.

17. The method of Claim 16, comprising fabricating said coherent light writing mask, the fabrication including:

- (i) creating a computerized file related to a pattern forming said coherent light writing mask, the pattern being indicative of morphology of said micro-optics structure defining said at least one lenslet array;
- (ii) applying at least one technique selected from diamond milling, soft lithography and direct writing to a glass plate, thereby forming said pattern having protrusions and cavities on a surface of the glass plate.

18. The method of Claim 17, wherein for a distance  $a$  between a top of the protrusions and a bottom of the cavities the following condition is fulfilled:

$$a \leq \frac{\lambda}{2(n_1 - n_2)},$$

where  $\lambda$  is the wavelength of the light;  $n_1$  and  $n_2$  are the refractive index of the material of the glass plate and the surrounding media, respectively.

19. The method of Claim 1, comprising:

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- (a) providing the substantially uniform layer of a predetermined thickness of the photosensitive material on the substrate;
- (b) applying a Soft-Baking to said substrate covered with the photosensitive material at a predetermined temperature over predetermined time period;
- 5 (c) applying the exposure to at least a portion of the substrate covered with the photosensitive material to light passing through the writing mask over a predetermined exposure time period;
- (d) applying a Post-Exposure-Baking to the substrate covered with the photosensitive material at a predetermined temperature over a predetermined
- 10 time period; and
- (e) gradually cooling the covered substrate after said Post-Exposure-Baking to a predetermined temperature.
20. The method of Claim 19, wherein said substrate is a plate made of large area glass.
- 15 21. The method of Claim 20, further comprising:
- (g) developing the covered substrate after the gradual cooling;
- (h) rinsing the covered substrate after the developing; and
- (i) drying the covered substrate after the rinsing.
22. The method of Claim 1, wherein the photosensitive material is located on
- 20 top of a glue layer carried by said substrate.
23. The method of Claim 19, wherein the uniform thickness of the layer of the photosensitive material is produced utilizing a spin-coating technique.
24. The method of Claim 19, wherein said substrate is a semiconductor wafer.
25. The method of Claim 22, wherein said substrate is a semiconductor wafer.
- 25 26. The method of Claim 24, further comprising:
- (g) developing the covered substrate after the gradual cooling;
- (h) rinsing the covered substrate after the developing; and
- (i) drying the covered substrate after the rinsing.
27. The method of Claim 19 and 25, further comprising:
- 30 (g) developing the covered substrate after the gradual cooling;

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(h) rinsing the covered substrate after the developing; and

(i) drying the covered substrate after the rinsing.

28. The method of any one of preceding Claims, wherein the photosensitive material is photoresist.
- 5 29. The method of Claim 28, wherein said photo-resist material is SU-8.
30. The method of Claim 19, wherein said providing of the uniform layer includes spinning the substrate at a speed required for obtaining said uniform photosensitive layer.
31. The method of Claim 29, wherein said predetermined temperature of said
- 10 Soft-Baking is in the range of 80°C -100 °C.
32. The method of Claim 29, wherein said predetermined time period of said Soft-Baking is in the range of 1 minutes to 3 minutes.
33. The method of Claim 19, wherein said light is applied to the photosensitive material at a predetermined angle.
- 15 34. The method of Claim 19, wherein said light is spatially incoherent UV light.
35. The method of Claim 29, wherein said light is spatially incoherent UV light characterized by specific energy between 200mW/cm<sup>2</sup> and 300mW/cm<sup>2</sup>.
36. The method of Claim 29, wherein said light is spatially incoherent UV light
- 20 applied over 0.5-1 minutes.
37. The method of Claim 19, wherein said light is spatially coherent UV light.
38. The method of Claim 29, wherein said light is spatially coherent UV light characterized by specific energy between 200mW/cm<sup>2</sup> and 300mW/cm<sup>2</sup>.
39. The method of Claim 29, wherein said light radiation is spatially coherent
- 25 UV light applied over 0.5-1 minutes.
40. The method of Claim 19, wherein said Post-Exposure-Baking is carried out in more than one stage.
41. The method of Claim 40, wherein said Post-Exposure-Baking is carried out in two stages.

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42. The method of Claim 41, wherein said predetermined temperature of said Post-Exposure-Baking at a first stage is in the range of about 60°C to 70 °C.

43. The method of Claim 40, wherein said predetermined time period of said Post-Exposure-Baking at a first stage is in the range of about 0.5 minutes to 1.5  
5 minutes.

44. The method of Claim 40, wherein said predetermined temperature of said Post-Exposure-Baking at a second stage is in the range of about 90°C to 100 °C.

45. The method of Claim 40, wherein said predetermined time period of said Post-Exposure-Baking at a second stage is in the range of about 0.5 minutes to 1.5  
10 minutes.

46. The method of Claim 19, wherein said predetermined temperature to which the substrate being gradually cooled after said Post-Exposure-Baking is a room temperature.

47. The method of Claim 19, wherein said developing of the covered substrate  
15 is carried out over the time range of about 2 minutes to 3 minutes.

48. The method of Claim 19, wherein said rinsing is carried out in an Isopropyl-Alcohol solution.

49. The method of Claim 19, wherein said drying is carried out in a stream of Nitrogen.

20 50. The method of Claim 22, wherein said glue layer is made of OP-4-20658.

51. The method of any one preceding claims comprising forming a flattening layer on top of the patterned layer of the photosensitive material.

52. The method of Claims 51, wherein the flattening layer is OP-44 material.

53. The method of Claims 22 to 52, comprising selecting thicknesses of the  
25 glue layer and the photosensitive layer so as to match a distance between the lenslet formed in the photosensitive material and a medium with which the lenslet array is used to affect light propagation therethrough.

54. The method of Claim 53, wherein said medium is a liquid crystal medium of an SLM.

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55. The method of any one of preceding Claims, wherein the distance between the writing mask and the photosensitive layer is within a range of 0-15 microns.

56. The method of any one of preceding Claims, wherein a dimension of the light transmitting region of the writing mask substantially does not exceed 5  
5 microns.

57. A Spatial Light Modulator (SLM) device manufactured by the method of any one of preceding Claims, the SLM comprising at least one lenslet array placed between a pixel arrangement and a glass substrate.